Evolution of Multi-Modal Digital Avionics

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Briefing Outline

- Motivation
- Flight Deck Evolution
- Centralized Architectures
- Disadvantages of Centralized Architectures
- Advanced Architectures

Motivation

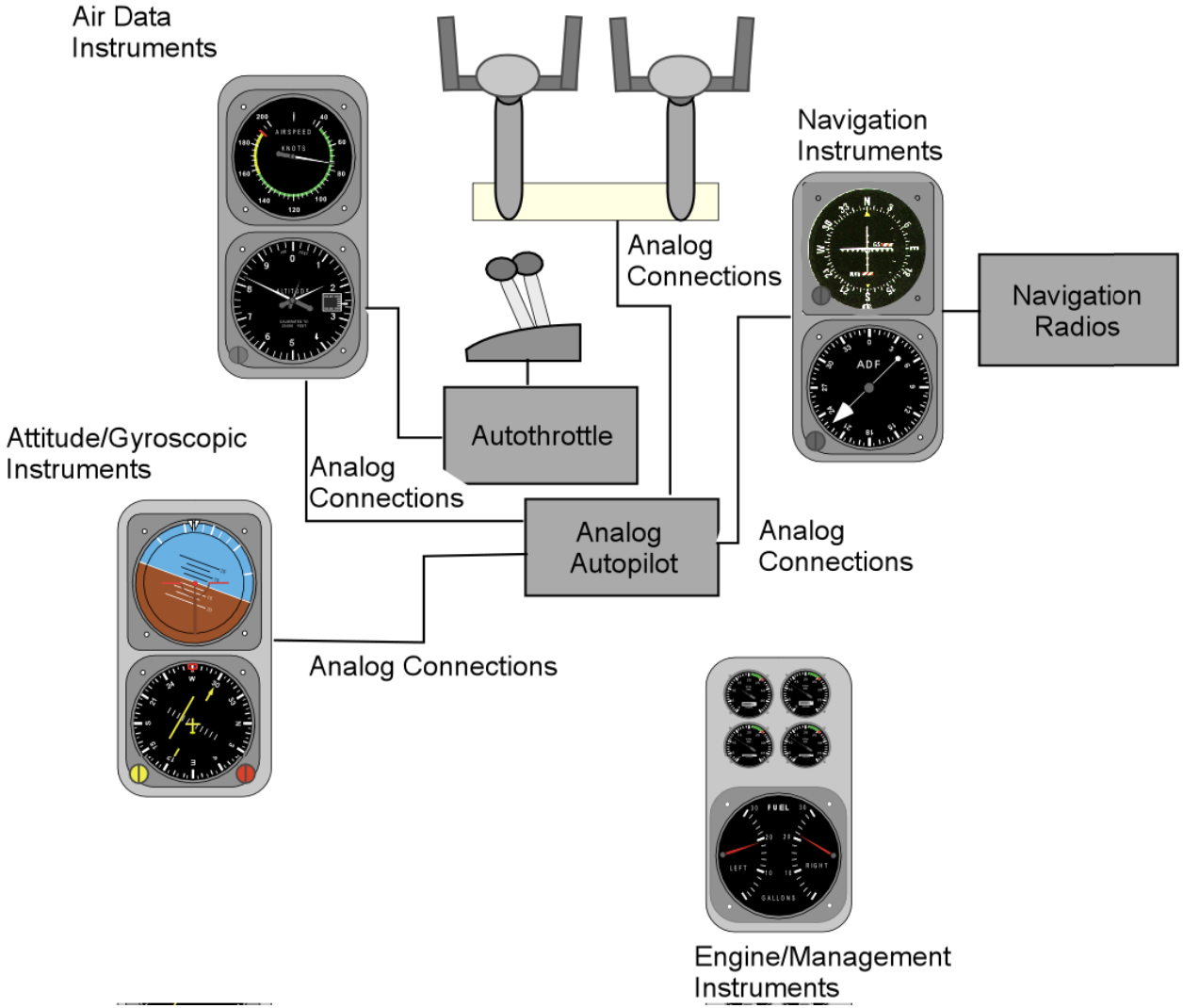
- **NASA Glenn Contract**
  - Survey of Multi-Modal Digital Avionics
- **Investigation Focus**
  - Description of the multiple functions and integrated modes within the MMDA design for today's commercial and business class aircraft;
  - Sequential or simultaneous operations, functions and modes;
  - Approach used for compliance with certification requirements;
  - Applicable AEEC, ARINC, ICAO, RTCA and other standards;
  - Use of open standards or company proprietary approaches for avionics design; and
  - Summary of hardware and software architectures employed.

Evolution of the Airliner Flight Deck

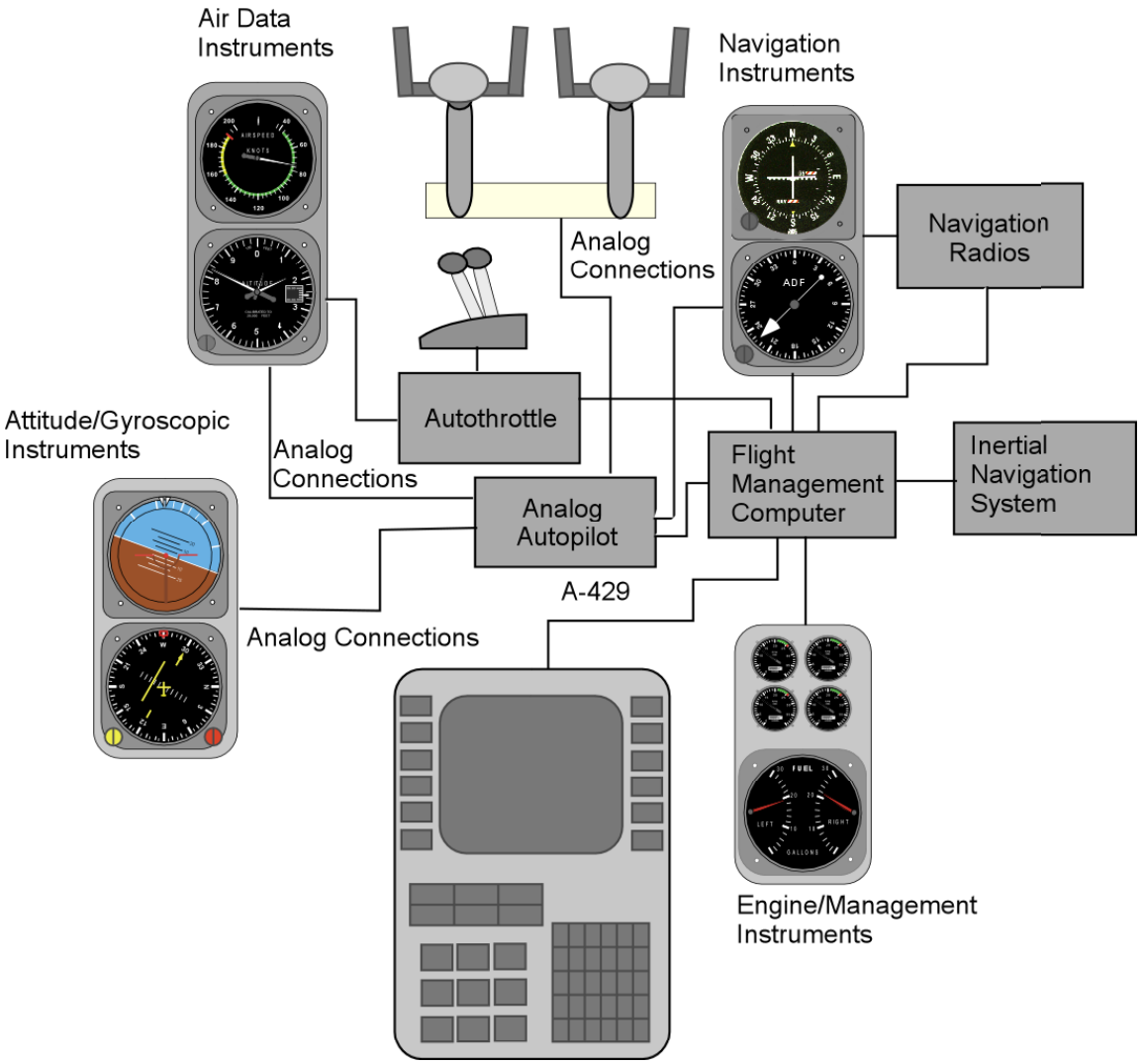
- **5 Stages of Evolution**

- **Electromechanical (non-FMS);**
- **Electromechanical with FMS;**
- **Hybrid / EFIS with FMS;**
- **Fully digital, distributed, glass cockpit.**
- **Centralized Computing Architecture.**

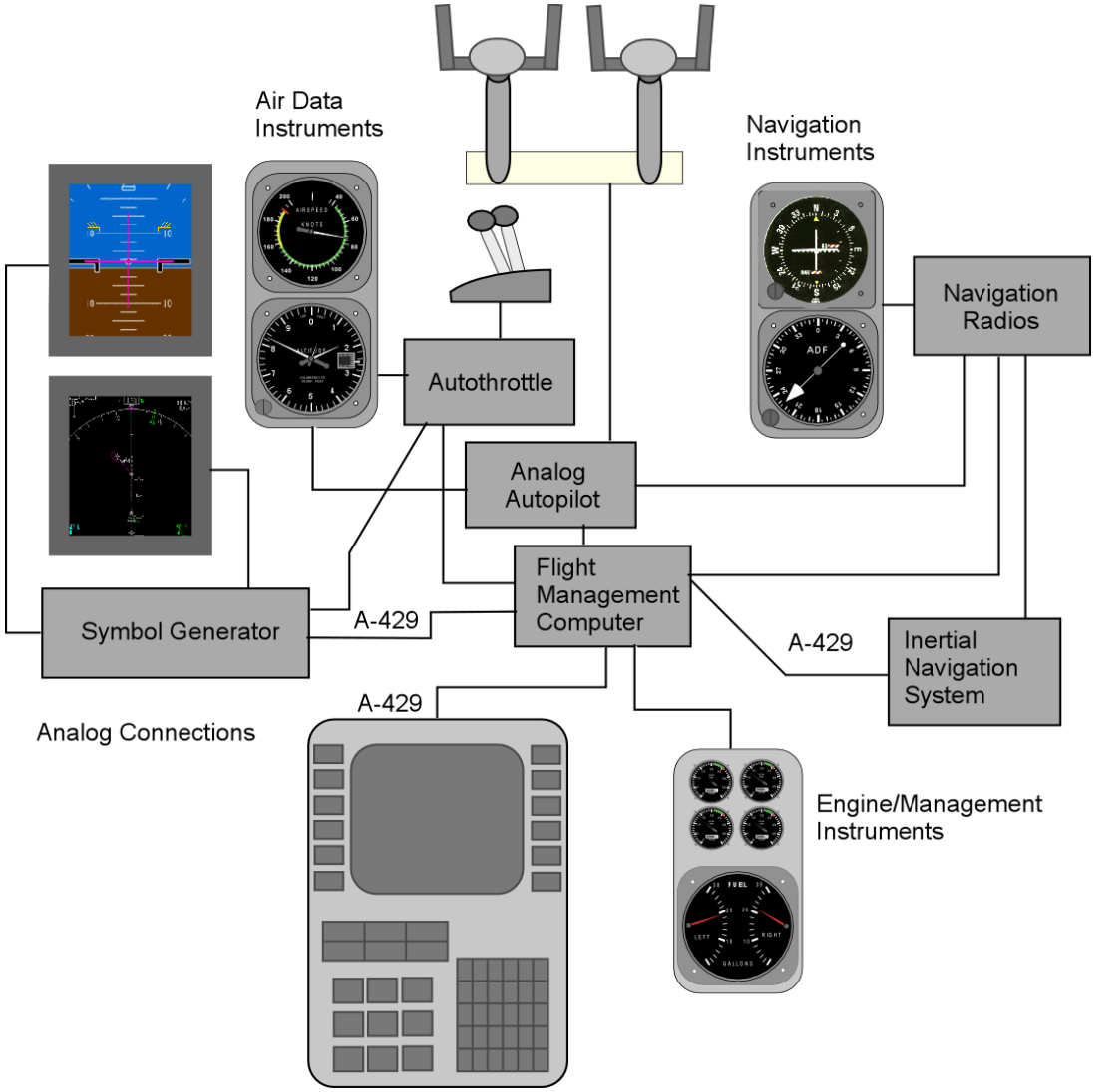
Electromechanical (no FMS)



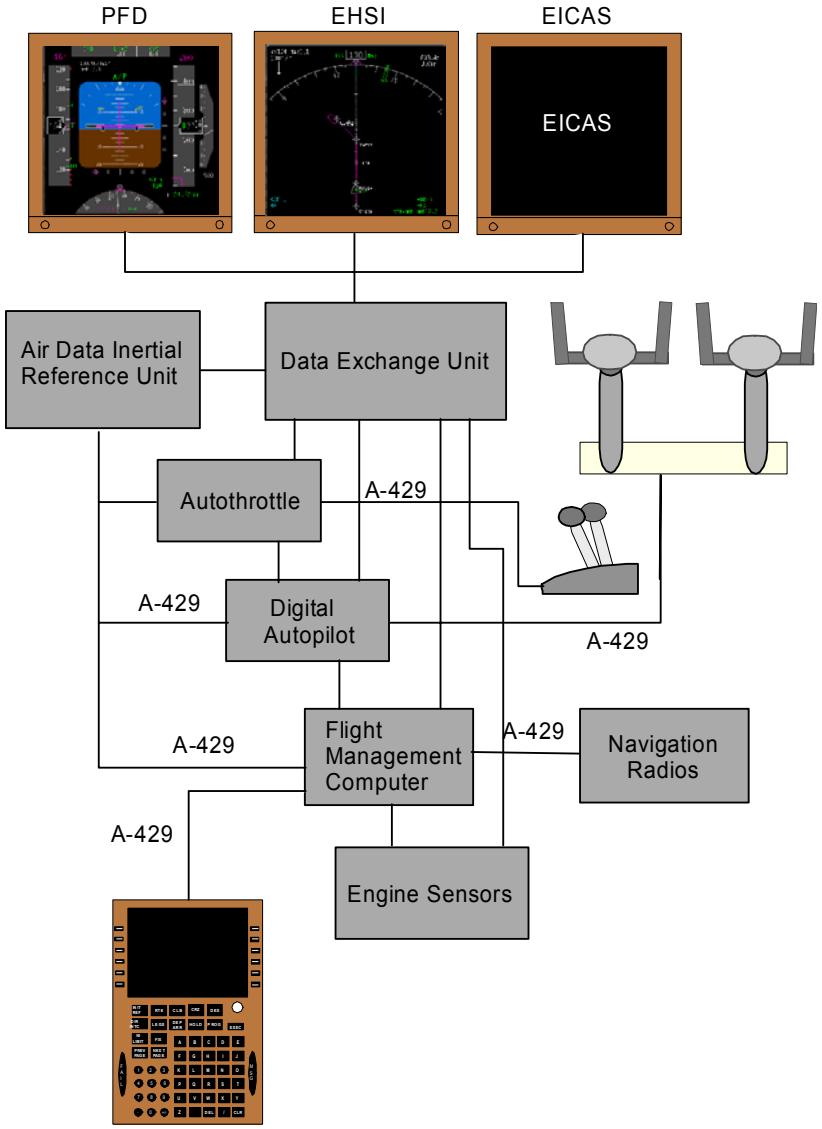
Electromechanical with FMS



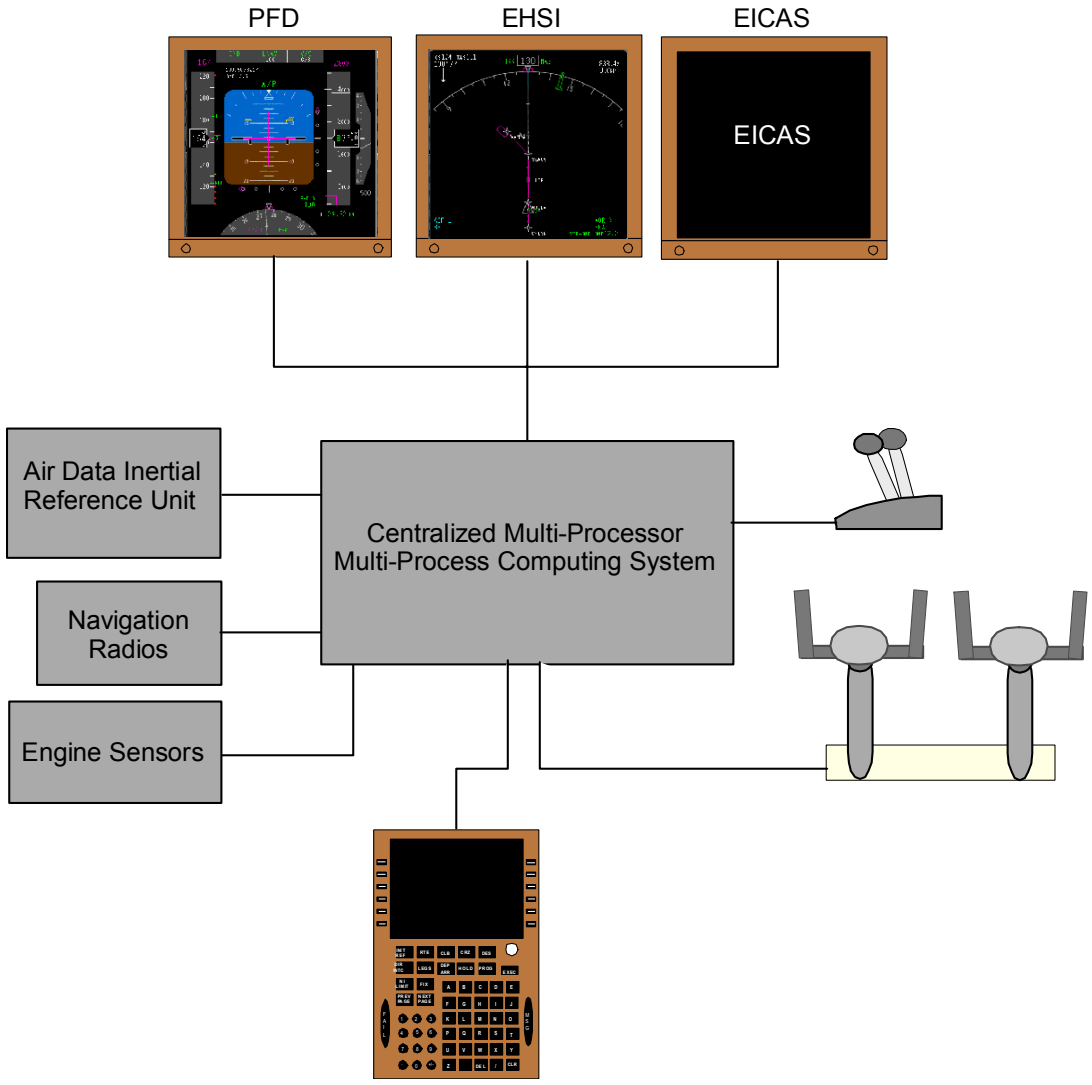
Hybrid / EFIS with FMS



Fully digital, distributed, glass cockpit

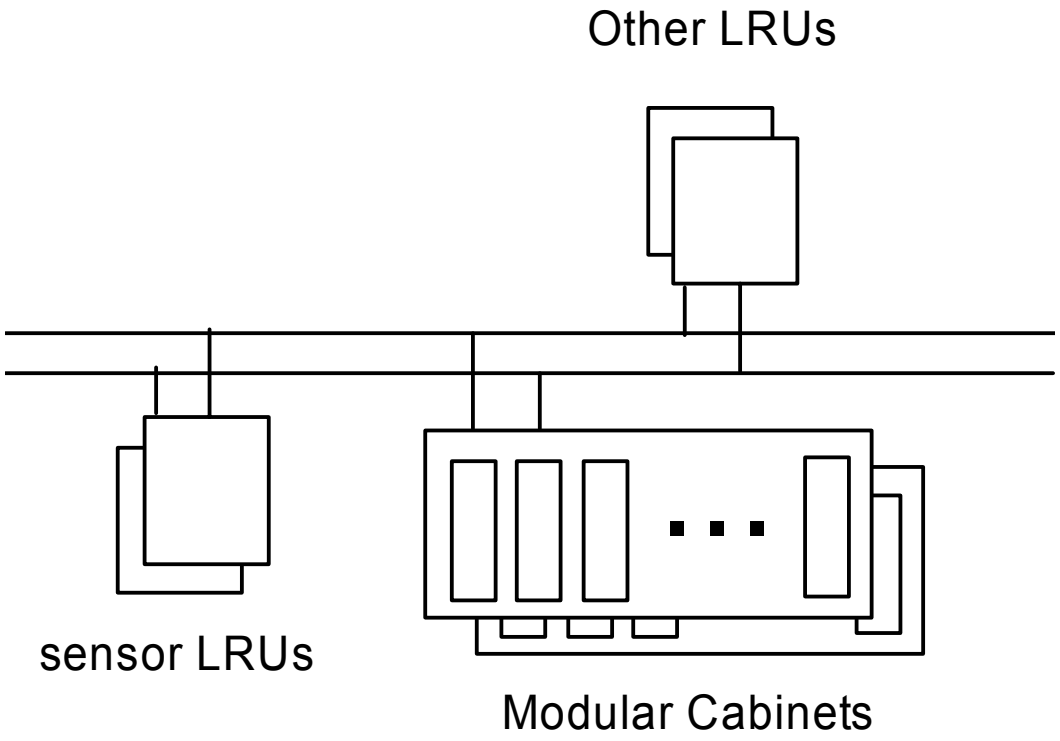


Centralized Computing Architecture



Centralized Architectures

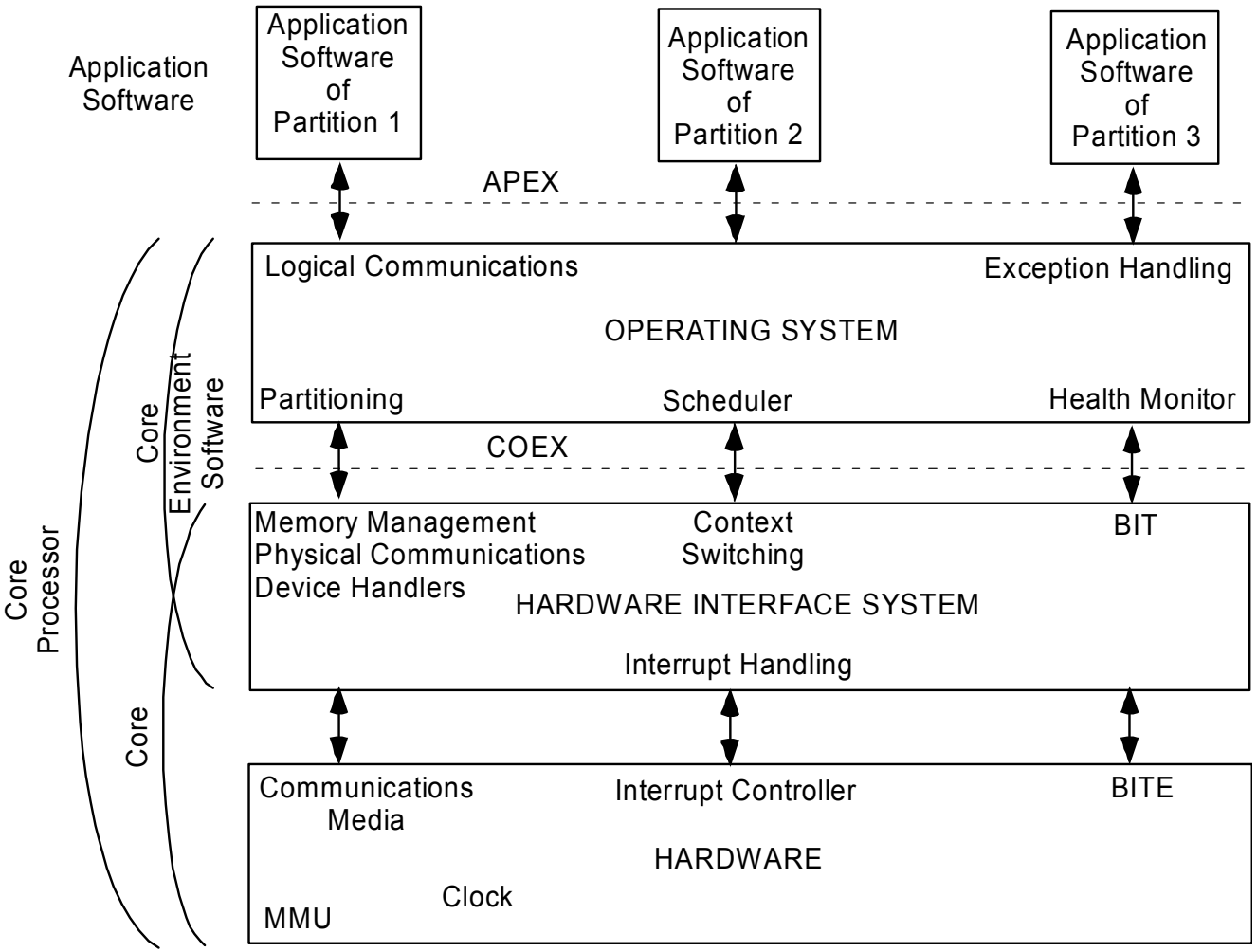
- **Integrated Modular Avionics (IMA)**
  - Replaces many single purpose LRUs (Line Replaceable Units)
  - Consists of “Modular Cabinets” with multiple CPUs
  - ARINC Report 651: "Design Guidance for Integrated Modular Avionics"



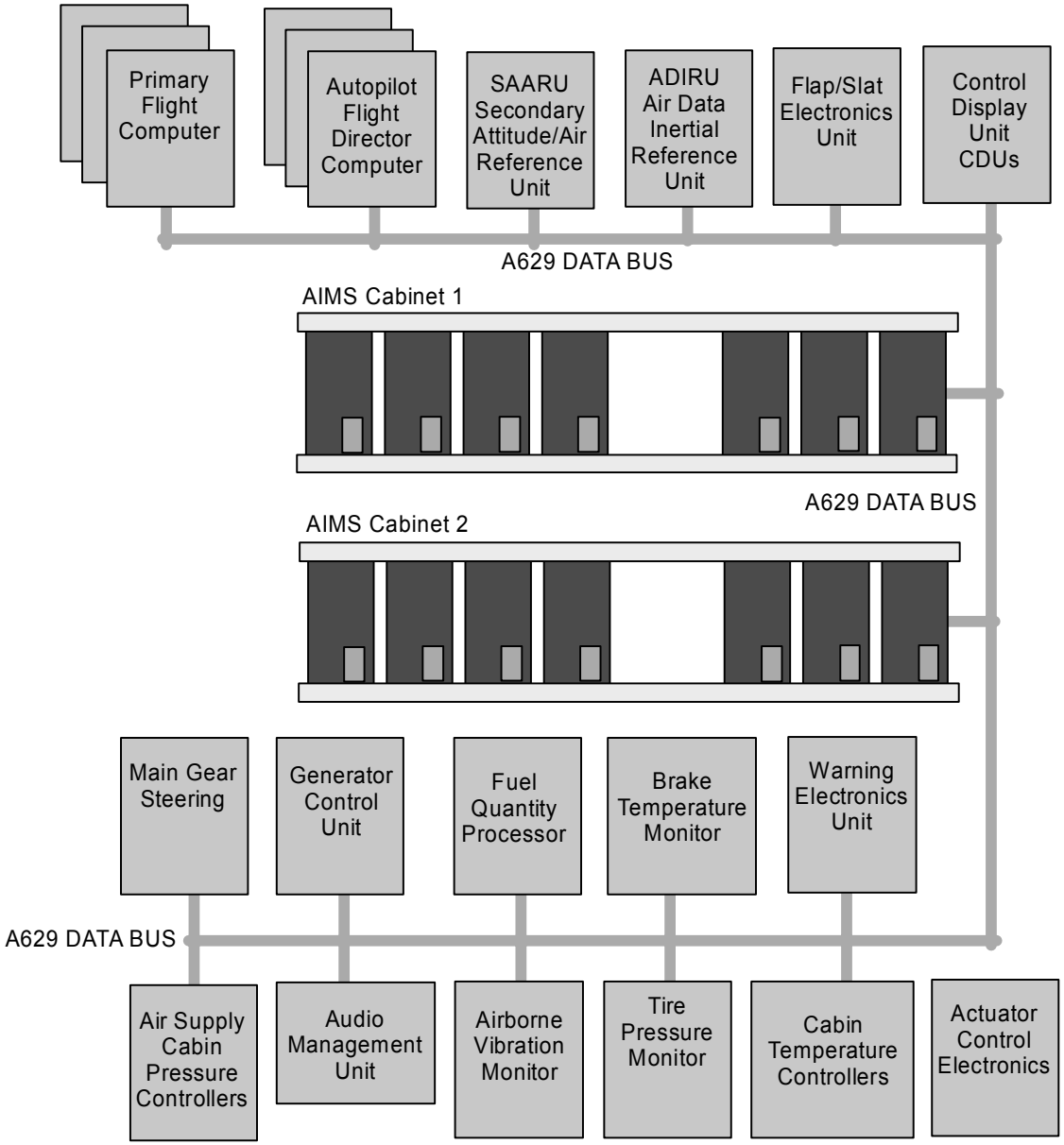
Software Partitioning

- One Operating System
- Multiple Applications

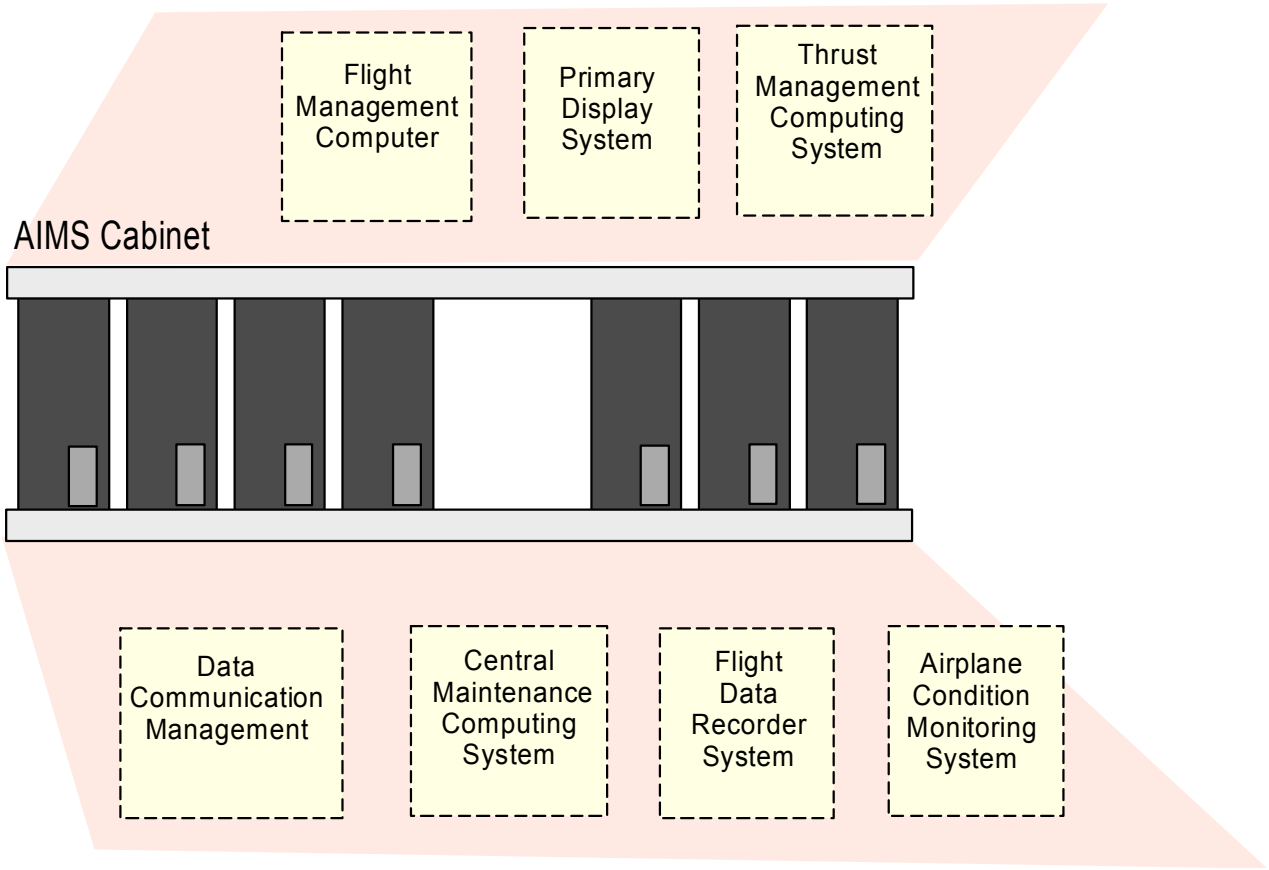
Software intensive



Boeing 777 Archictecture



Boeing 777 AIMS Cabinet



Illustrates the different processes on an AIMS cabinet

Advanced Regional/Business Jet Architectures

- **Honeywell Primus Epic**
  - Large business jets
  - Cessna Sovereign
  - Based on Primus 1000-2000 series
  - New IMA architecture

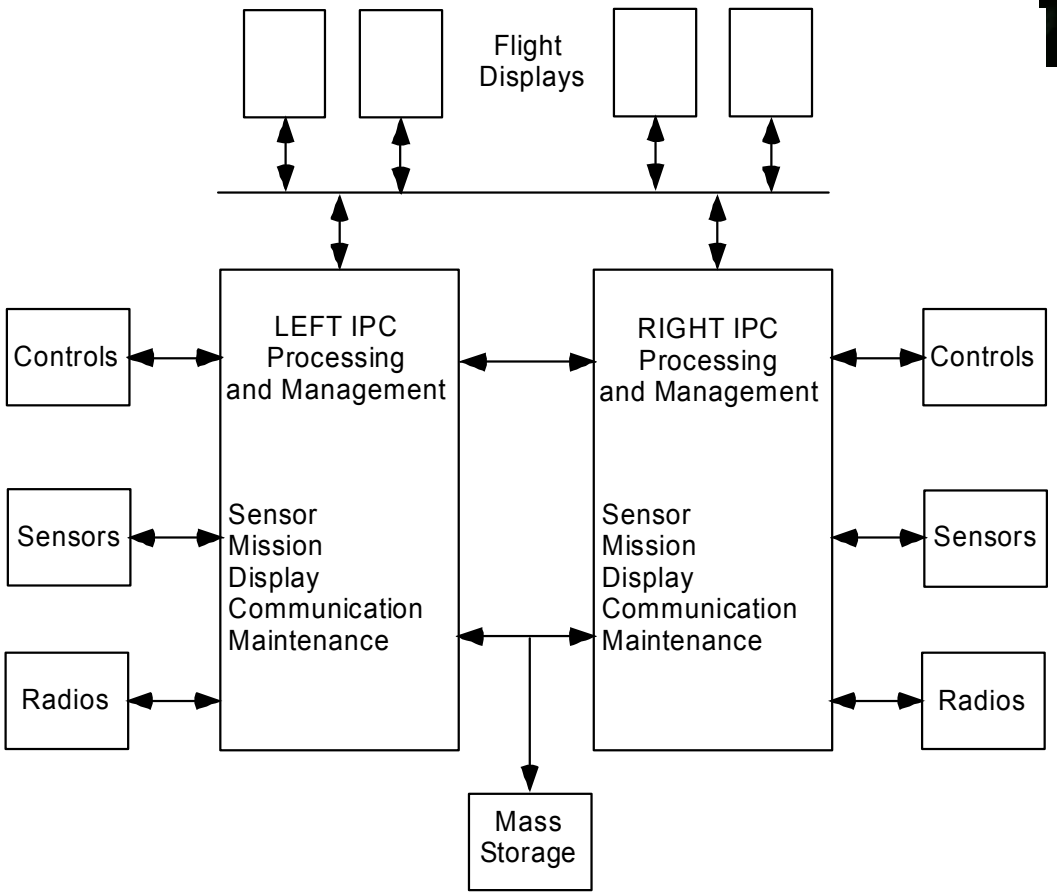
- **Collins Pro Line 21**
  - Smaller business Jets
  - Turbo prop aircraft

Primus Epic

- **Blends B-777 AIMS cabinet with Primus 2000**
- **Features**
  - Integrated Sensor Suite
    - Air Data Computer(ADC)
    - Inertial Reference System (IRS)
    - Attitude/Heading Reference System(AHRS)
  - Integrated Radio and Audio System
    - VOR, ADF, DME, ILS, VHF, Mode S
  - Human Factors Design
    - Cursor Control Device (like B-777)
  - DEOS (digital engine operating system)
    - A computer operating system for that handles the partitioning of different applications

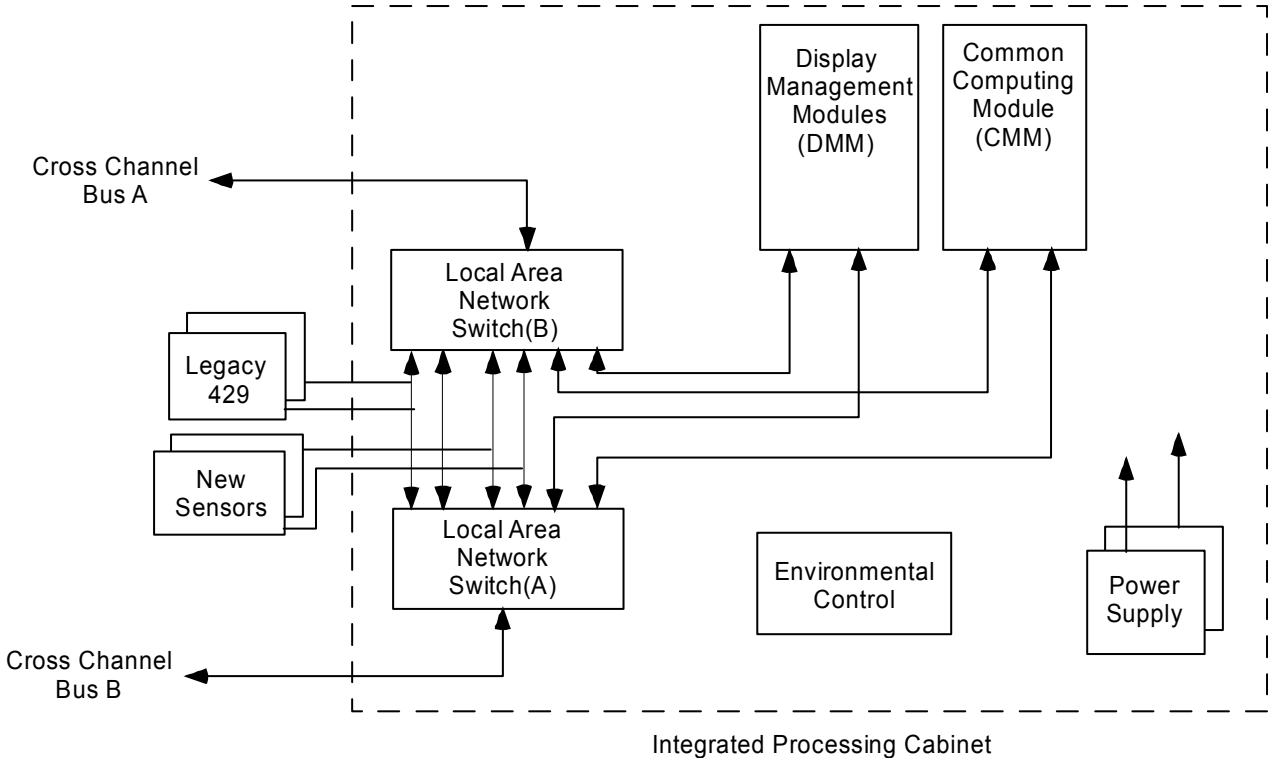
Pro Line 21

- **Advanced Avionics System Architecture**
- **Integrated Processing Cabinet, IPC**



Pro Line 21

- **Each IPC**
  - Display Management Module
  - Common computing module
  - 2 Local area network switches

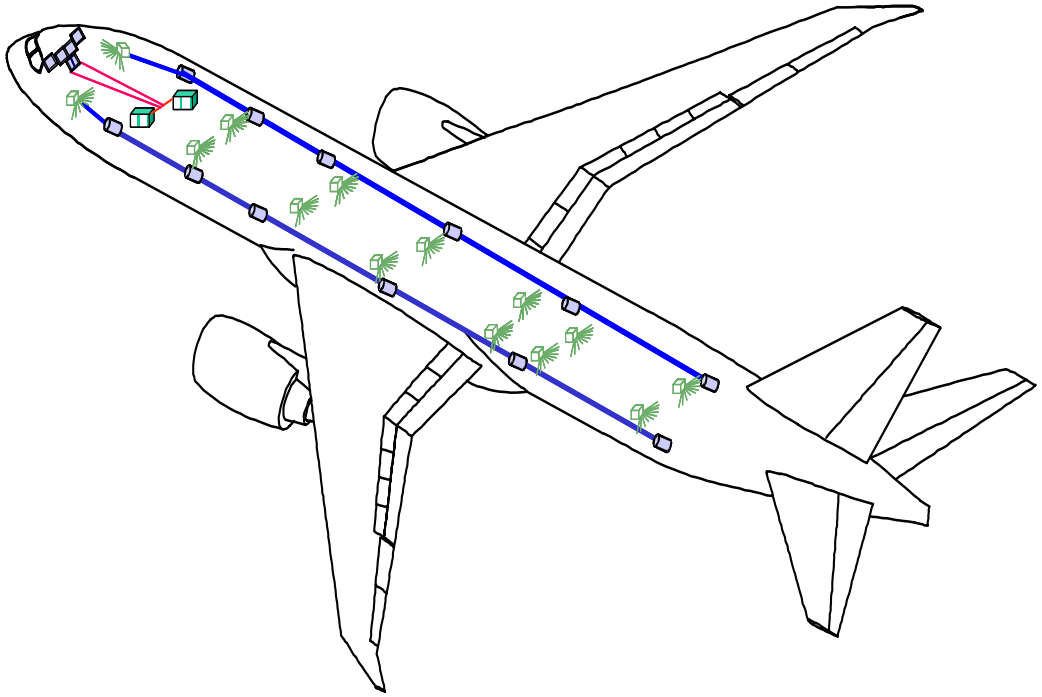


Centralized Architecture Disadvantages

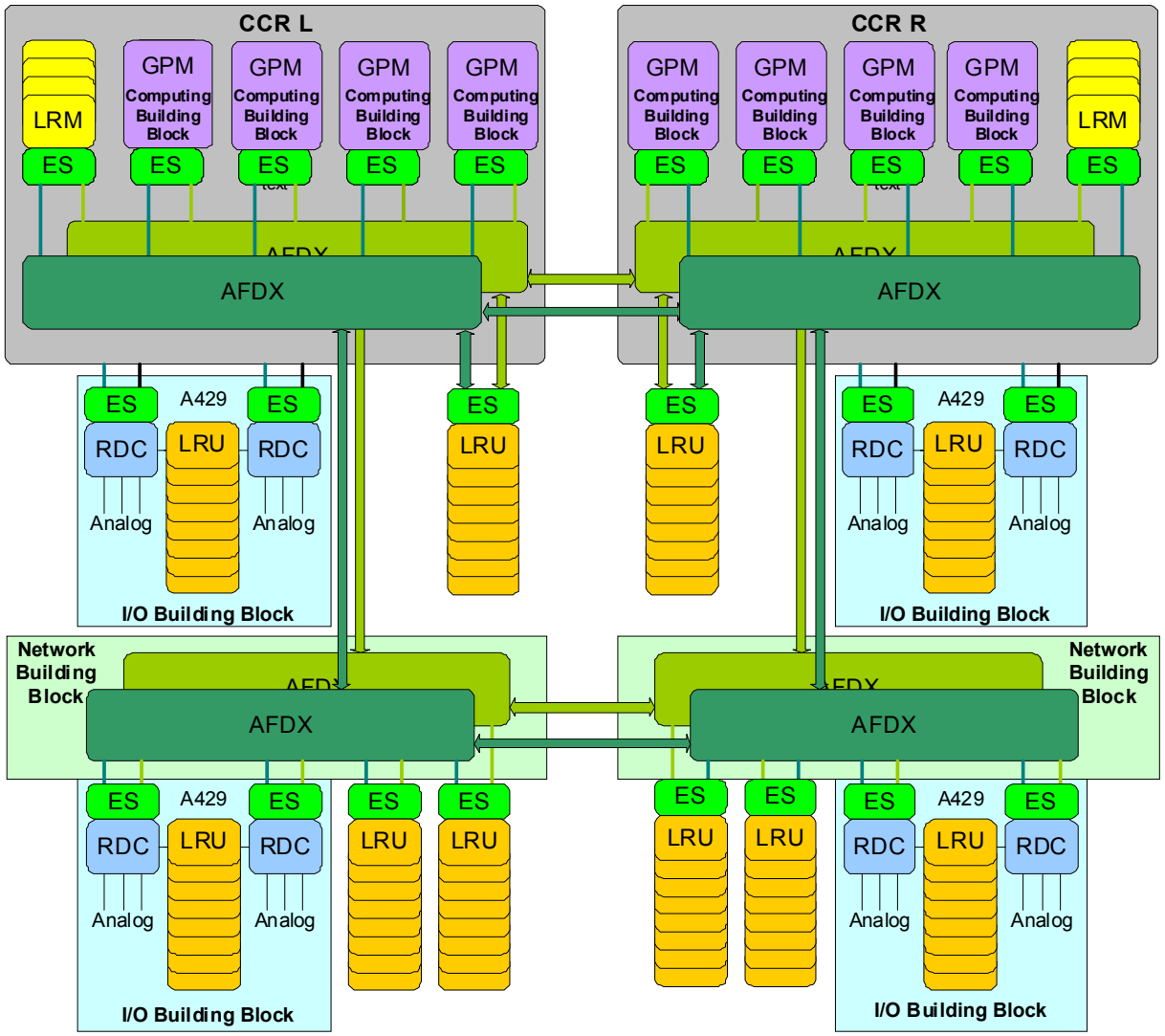
- **Software development is more expensive than hardware**
  - consumes 70-80% of the development budget for new avionics
  - Operating systems need to be complex
  - Software applications need to be designed to be hardware independent
- **Hardware is becoming smaller, lighter, and less expensive**
- **High speed Buses**
  - FDX (Full Duplex Ethernet) buses are 100 Mbps compared to ARINC 429 at 12-100 Kbps
  - Reduces wiring
  - Makes distributed architecture faster and less costly
- **Smart Peripherals**
  - Do not need to rely on a centralized computing resource
  - Peripherals can plug directly into a network

Smiths Proposed 7E7 Flight Deck

- Uses Centralized Computing Architecture in addition to smart peripherals
- Uses AFDX data bus to create Common Data Network
- Remote data concentrators provide access for analog and legacy 429 devices



Smiths Proposed 7E7 Architecture

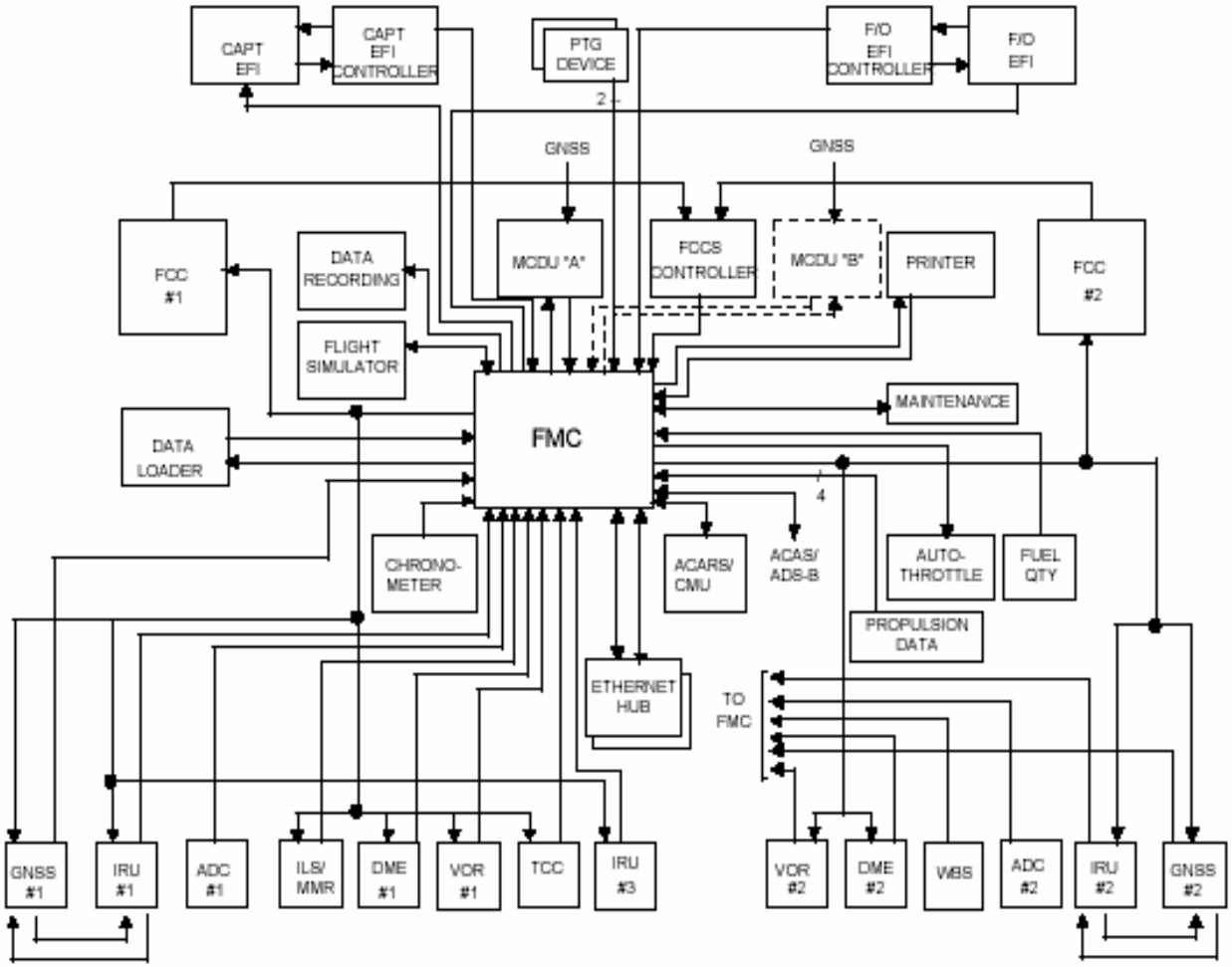


Flight Management Systems

- **FMS Functionality as Defined in ARINC 702A-1**
  - Flight Planning;
  - Lateral and Vertical Navigation;
  - Performance (Fuel burn and time of flight) Calculations Function;
  - Airline Operational Control (AOC) Function;
  - CNS/ATM Functions;
  - Airport Surface Guidelines;
  - Terrain and Obstacle Data; (Future features)
  - Navigation Display Interface;
  - CMU Interface;
  - Integrity Monitoring and Alerting.

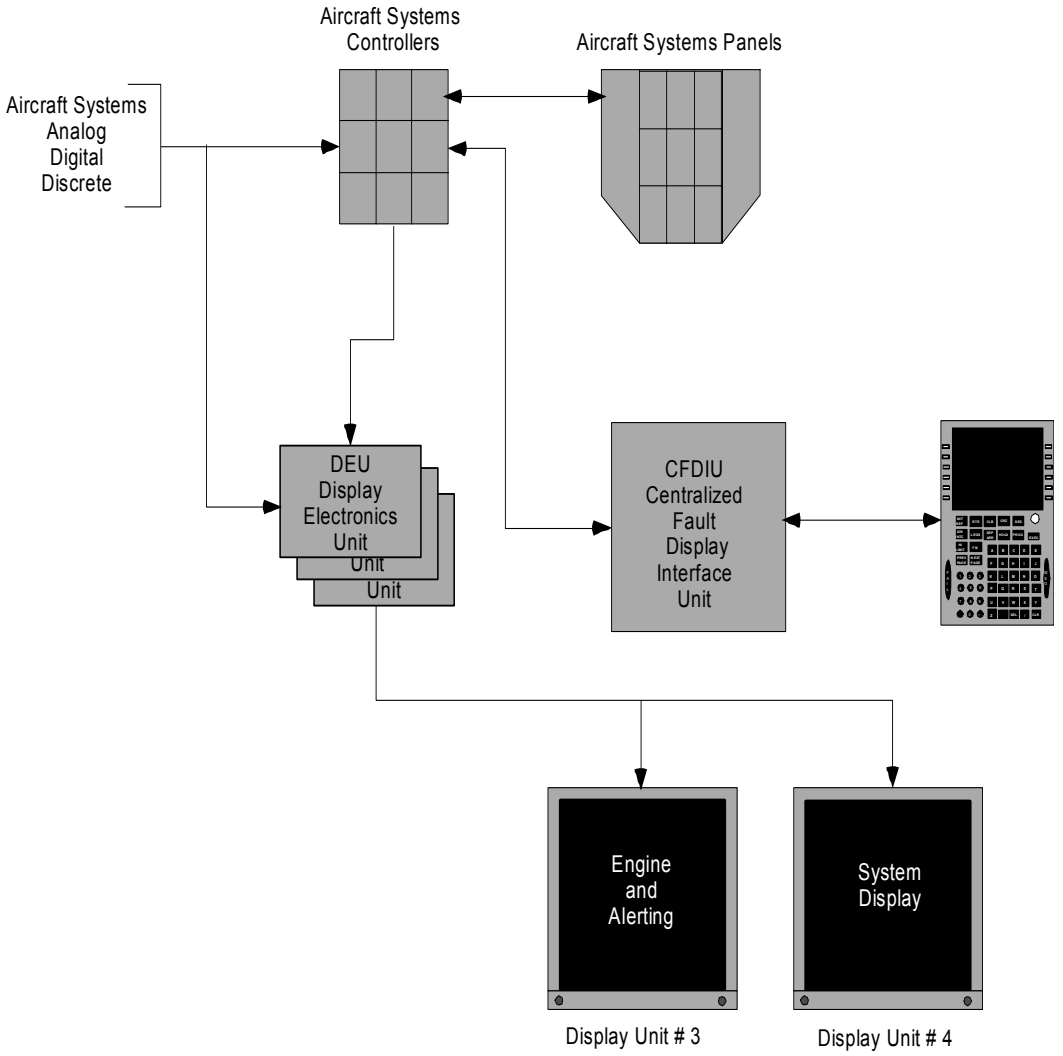
Flight Management Systems

Major example of digital avionics benefit



Aircraft System Controllers

- **Aircraft System Controllers**
  - Automated management of : Air, Fuel, Electric and Hydraulic Systems
  - Eliminated the need for a flight engineer
  - Dark cockpit Philosophy (No lights- normal operation)
  - Manual backup possible



Consolidated Hardware

- **Primus Epic digital remote mounted radio system**
  - VOR, ADF, DME, ILS, VHF Communication and Mode S Transponder

- **Rockwell Collins NAV-4000**
  - (VOR/ILS/MKR) and ADF functionality in a single LRU.

Extreme Consolidation Example

- **Garmin GNS – 530 (Light General Aviation)**

- **WAAS-upgradeable IFR GPS**
- **Lateral path guidance**
- **Com Radio**
- **VOR /LOC**
- **Glide-slope**
- **Color moving map**
- **Jeppesen database**
  - airports, VORs,
  - NDBs, Intersections,
  - FSS, Approach,
  - DPs/STARs and SUA

Cockpit Automation

- **Flight Management Systems**
  - Revolutionize the way airplanes are flown
- **Management of Complex Systems**
  - Aircraft System Controllers
  - Automation of Flight Engineer Role
  - Major feature of MD-11
  - Built in Maintenance Manuals and Fault Isolation Manuals

Major Themes

- **2 Major Themes Emerged**
  - Automation and Consolidation
  - Centralized Architectures
- **Theme 1: Automation and Consolidation**
  - Digital Avionics allows a level of automation previously not possible
  - Design trend: consolidate functions and modes previously performed by separate units into a single package
- **Theme 2: Centralized Architecture**
  - Digital avionics architecture has evolved away from distributed digital systems
  - Multiple processes running on 1 computing device